

1. What is the total electrical energy used by a 1500-watt hair dryer operating for 6.0 minutes?

- |          |                        |
|----------|------------------------|
| 1) 4.2 J | 3) $9.0 \times 10^3$ J |
| 2) 250 J | 4) $5.4 \times 10^5$ J |

2. Your school's physics laboratory has the following equipment available for conducting experiments:

accelerometers	lasers	stopwatches
ammeters	light bulbs	thermometers
bar magnets	meter sticks	voltmeters
batteries	power supplies	wires
electromagnets	spark timers	

Explain how you would find the resistance of an unknown resistor in the laboratory. Your explanation must include:

*a* Measurements required

*b* Equipment needed

*c* Complete circuit diagram

*d* Any equation(s) needed to calculate the resistance

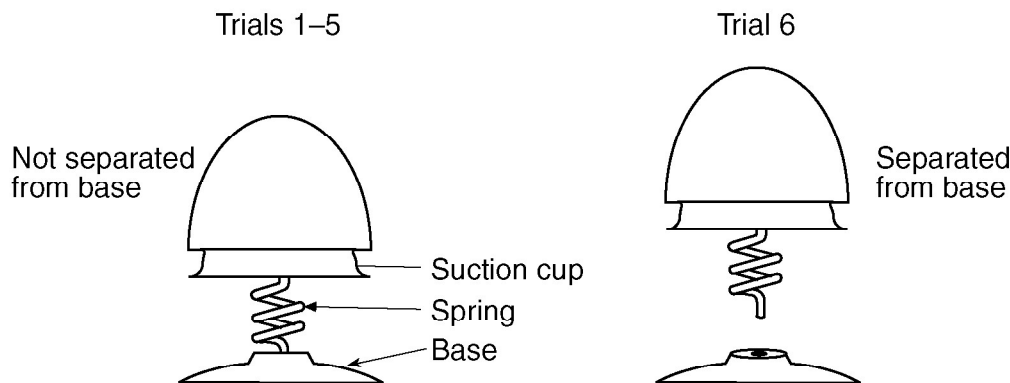
Base your answers to questions 3 and 4 on the information below and on your knowledge of physics.

Using a spring toy like the one shown in the diagram, a physics teacher pushes on the toy, compressing the spring, causing the suction cup to stick to the base of the toy.

When the teacher removes her hand, the toy pops straight up and just brushes against the ceiling. She does this demonstration five times, always with the same result.

When the teacher repeats the demonstration for the sixth time the toy crashes against the ceiling with considerable force. The students notice that in this trial, the spring and toy separated from the base at the moment the spring released.

The teacher puts the toy back together, repeats the demonstration and the toy once again just brushes against the ceiling.



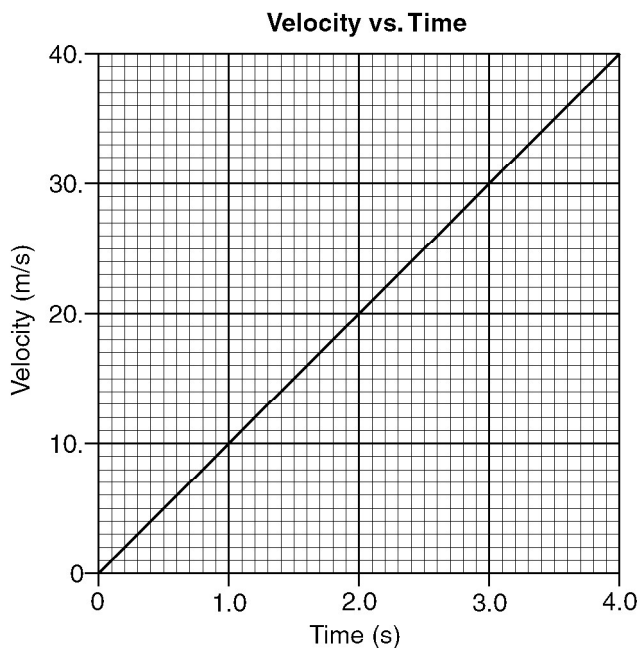
3. Describe the conversions that take place between pairs of the three forms of mechanical energy, beginning with the work done by the teacher on the toy and ending with the form(s) of energy possessed by the toy as it hits the ceiling. [Neglect friction.]
  4. Explain, in terms of mass and energy, why the spring toy hits the ceiling in the sixth trial and not in the other trials.
- 
5. A catapult with a spring constant of  $1.0 \times 10^5$  newtons per meter is required to launch an airplane from the deck of an aircraft carrier. The plane is released when it has been displaced 0.50 meter from its equilibrium position by the catapult. The energy acquired by the airplane from the catapult during takeoff is approximately
    - 1)  $1.3 \times 10^5$  J
    - 2)  $2.0 \times 10^5$  J
    - 3)  $2.5 \times 10^5$  J
    - 4)  $1.0 \times 10^6$  J
  6. A 10.-ohm resistor and a 20.-ohm resistor are connected in series to a voltage source. When the current through the 10.-ohm resistor is 2.0 amperes, what is the current through the 20.-ohm resistor?
    - 1) 1.0 A
    - 2) 2.0 A
    - 3) 0.50 A
    - 4) 4.0 A

Base your answers to questions 7 and 8 on the information given below.

Friction provides the centripetal force that allows a car to round a circular curve.

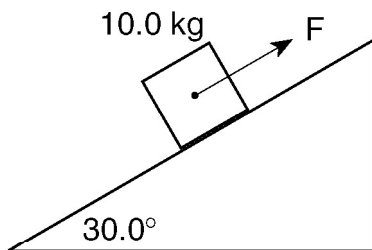
7. Find the minimum coefficient of friction needed between the tires and the road to allow a 1600-kilogram car to round a curve of radius 80. meters at a speed of 20. meters per second. [Show all work, including formulas and substitutions with units.]
8. If the mass of the car were increased, how would that affect the maximum speed at which it could round the curve?

9. The graph below shows the velocity of a race car moving along a straight line as a function of time.



What is the magnitude of the displacement of the car from  $t = 2.0$  seconds to  $t = 4.0$  seconds?

- |          |          |
|----------|----------|
| 1) 20. m | 3) 60. m |
| 2) 40. m | 4) 80. m |
10. The diagram below shows a 10.0-kilogram mass held at rest on a frictionless  $30.0^\circ$  incline by force  $F$ .



What is the approximate magnitude of force  $F$ ?

- |           |           |
|-----------|-----------|
| 1) 9.81 N | 3) 85.0 N |
| 2) 49.1 N | 4) 98.1 N |

11. In a demonstration, a vibrating tuning fork causes a nearby second tuning fork to begin to vibrate with the same frequency. Which wave phenomenon is illustrated by this demonstration?

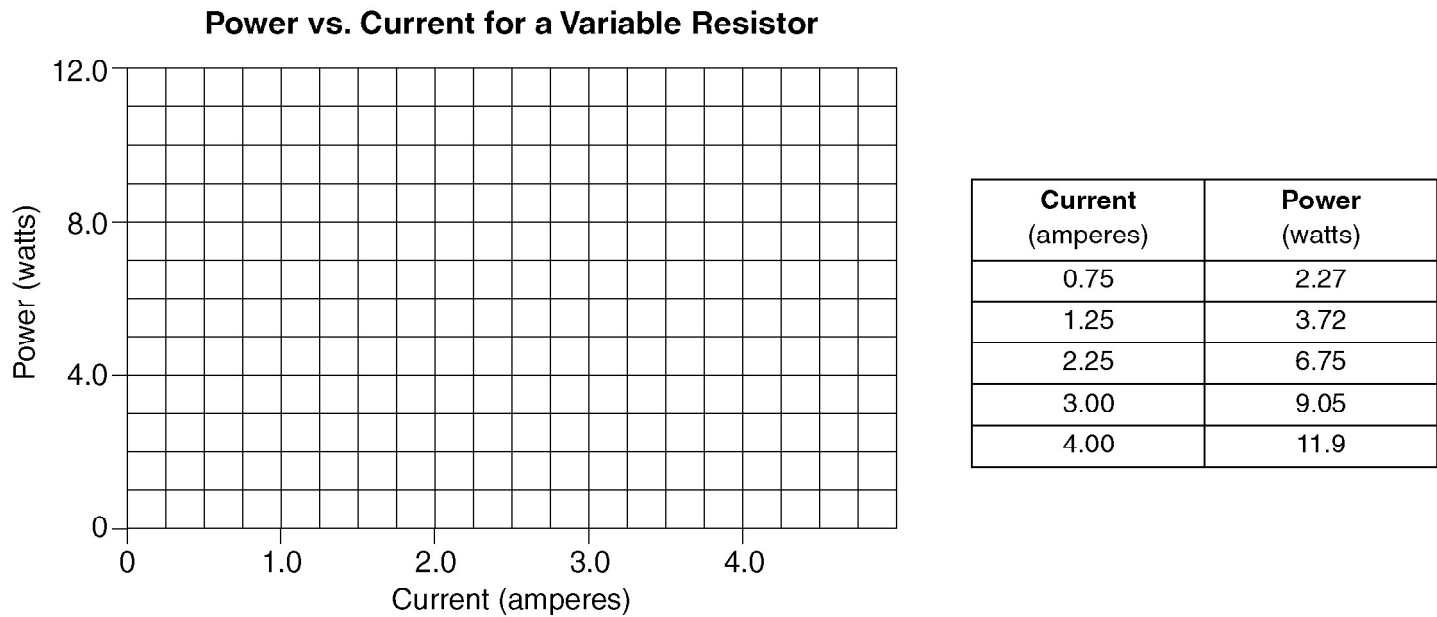
- |                       |                 |
|-----------------------|-----------------|
| 1) the Doppler effect | 3) nodes        |
| 2) resonance          | 4) interference |

12. An archer uses a bow to fire two similar arrows with the same string force. One arrow is fired at an angle of  $60.^\circ$  with the horizontal, and the other is fired at an angle of  $45.^\circ$  with the horizontal. Compared to the arrow fired at  $60.^\circ$ , the arrow fired at  $45.^\circ$  has a

- |   |
|---|
| 1) longer flight time and longer horizontal range   |
| 2) shorter flight time and shorter horizontal range |
| 3) shorter flight time and longer horizontal range  |
| 4) longer flight time and shorter horizontal range  |

Base your answers to questions 13 through 16 on the information and data table below.

A variable resistor was connected to a battery. As the resistance was adjusted, the current and power in the circuit were determined. The data are recorded in the table below.



13. Using the information in the data table, construct a line graph on the grid provided *above*, following the directions below.

- a Plot the data points for power versus current.
- b Draw the best-fit line.

14. Calculate the slope of the graph. [Show all calculations, including the equation and substitution with units.]

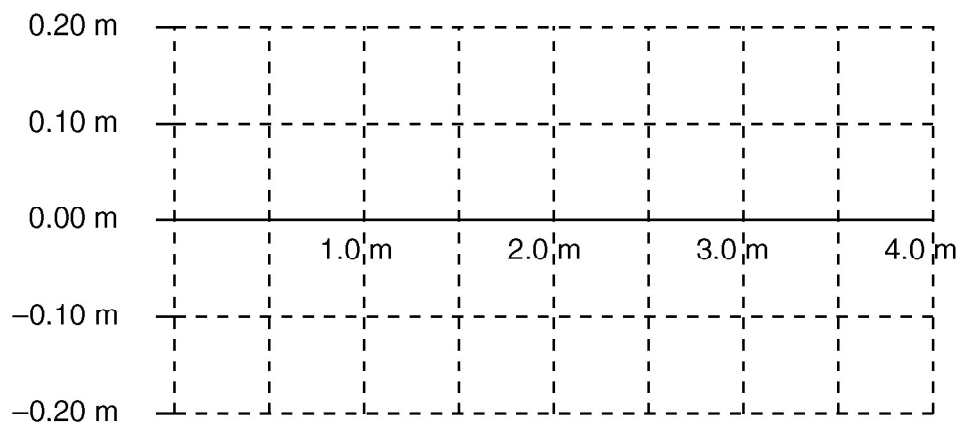
15. What is the physical significance of the slope of the graph?

16. Using your graph, determine the power delivered to the circuit at a current of 3.5 amperes.

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Base your answers to questions 17 and 18 on the information below.

A periodic transverse wave has an amplitude of 0.20 meter and a wavelength of 3.0 meters.

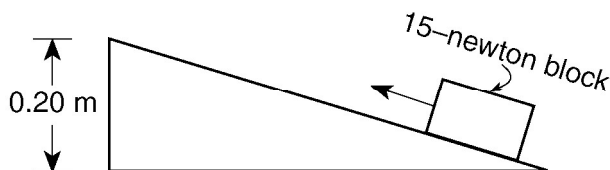


17. If the frequency of this wave is 12 Hz, what is its speed?

- 1) 0.25 m/s      2) 12 m/s      3) 36 m/s      4) 4.0 m/s

18. On the grid provided *above*, draw at least one cycle of this periodic wave.

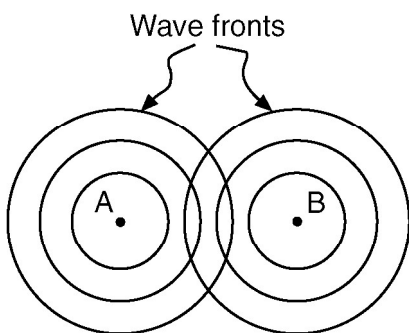
19. A block weighing 15 Newtons is pulled to the top of an incline that is 0.20 meter above the ground, as shown below.



If 4.0 joules of work are needed to pull the block the full length of the incline, how much work is done against friction?

- 1) 1.0 J      2) 0.0 J      3) 3.0 J      4) 7.0 J

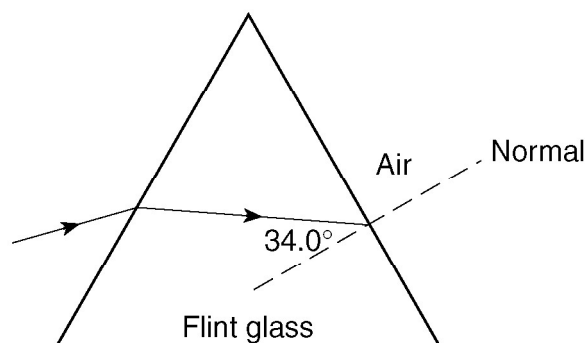
20. The diagram below represents the wave pattern produced by two sources located at points A and B.



Which phenomenon occurs at the intersections of the circular wave fronts?

- 1) refraction      2) reflection      3) diffraction      4) interference

Base your answers to questions 21 through 23 on the diagram below which shows a ray of monochromatic light ( $f = 5.09 \times 10^14$  hertz) passing through a flint glass prism.



21. Calculate the angle of refraction (in degrees) of the light ray as it enters the air from the flint glass prism. [Show all calculations, including the equation and substitution with units.]

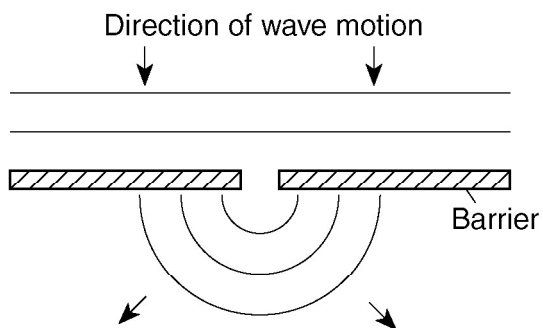
22. What is the speed of the light ray in flint glass?

- 1)  $5.53 \times 10^8$  m/s      2)  $1.81 \times 10^8$  m/s      3)  $3.00 \times 10^8$  m/s      4)  $4.98 \times 10^8$  m/s

23. Using a protractor and a straightedge, construct the refracted light ray in the air on the diagram *above*.

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24. The diagram below shows wave fronts spreading into the region behind a barrier.



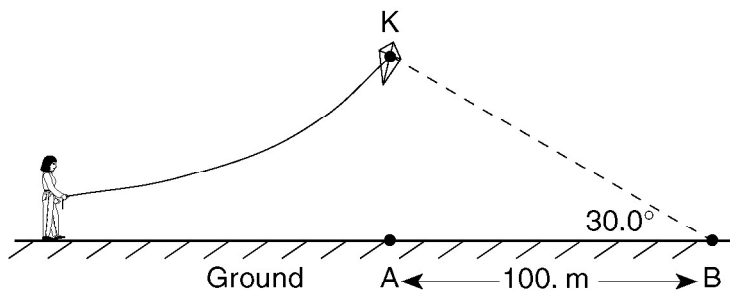
Which wave phenomenon is represented in the diagram?

- |                   |                |
|-------------------|----------------|
| 1) reflection     | 3) refraction  |
| 2) standing waves | 4) diffraction |
25. What is the approximate electrostatic force between two protons separated by a distance of  $1.0 \times 10^{-10}$  meter?

- |  |
|--|
| 1) $9.0 \times 10^{-8}$ N and attractive |
| 2) $9.0 \times 10^{-8}$ N and repulsive  |
| 3) $2.3 \times 10^{-8}$ N and repulsive  |
| 4) $2.3 \times 10^{-8}$ N and attractive |

Base your answers to questions 26 through 28 on the information and diagram below.

A child is flying a kite,  $K$ . A student at point  $B$ , located 100. meters away from point  $A$  (directly underneath the kite), measures the angle of elevation of the kite from the ground as  $30.0^\circ$ .

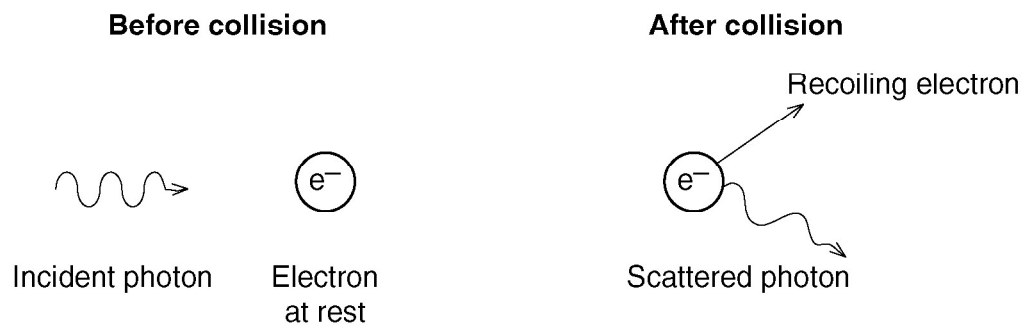


Scale  
1.0 cm = 10. m



26. Use a metric ruler and your scale diagram to determine the height,  $AK$ , of the kite.
27. *In the space provided above*, use a metric ruler and protractor to draw a triangle representing the positions of the kite,  $K$ , and point  $A$  relative to point  $B$  that is given. Label points  $A$  and  $K$ . Use a scale of 1.0 centimeter = 10. meters.
28. A small lead sphere is dropped from the kite. Calculate the amount of time required for the sphere to fall to the ground. [Show all calculations, including the equation and substitution with units. Neglect air resistance.]
- 
29. After electrons in hydrogen atoms are excited to the  $n = 3$  energy state, how many different frequencies of radiation can be emitted as the electrons return to the ground state?
- 1) 1                                      3) 3  
2) 2                                      4) 4
30. Determine the color of a ray of light with a wavelength of  $6.21 \times 10^{-7}$  meter.
- 
31. In raising an object vertically at a constant speed of 2.0 meters per second, 10. watts of power is developed. The weight of the object is
- 1) 5.0 N                                      3) 40. N  
2) 20. N                                      4) 50. N

Base your answers to questions 32 and 33 on the information and diagram below. The diagram shows the collision of an incident photon having a frequency of  $2.00 \times 10$  hertz with an electron initially at rest.



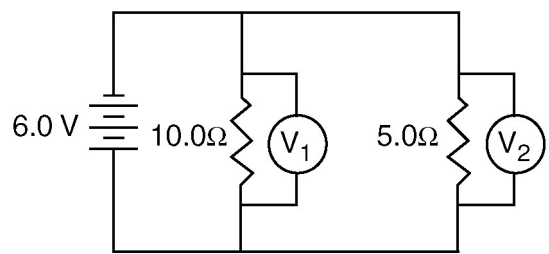
32. What is the total energy of the two-particle system after the collision?
33. Calculate the initial energy of the photon. [Show all calculations, including the equation and substitution with units.]

- |   |  |
|---|--|
| 34. If the magnitude of the gravitational force of Earth on the Moon is $F$ , the magnitude of the gravitational force of the Moon on Earth is<br>1) smaller than $F$ 3) larger than $F$<br>2) equal to $F$ | 37. Approximately how much time does it take the radio signal to travel from Earth to the spaceship?<br>1) $4.11 \times 10^{-8}$ s                      3) $2.19 \times 10^{-8}$ s<br>2) $2.43 \times 10^{-8}$ s                      4) $1.46 \times 10^{-8}$ s |
| 35. Which is an acceptable unit for impulse?<br>1) $\text{kg}\cdot\text{m/s}$ 3) $\text{N}\cdot\text{m}$<br>2) $\text{J/s}$ 4) $\text{J}\cdot\text{s}$  | 38. Which term represents a scalar quantity?<br>1) displacement                      3) weight<br>2) distance                      4) force  |

Base your answers to questions 36 and 37 on the information below.

A  $2.00 \times 10^8$ -hertz radio signal is sent a distance of  $7.50 \times 10^8$  meters from Earth to a spaceship orbiting Mars.

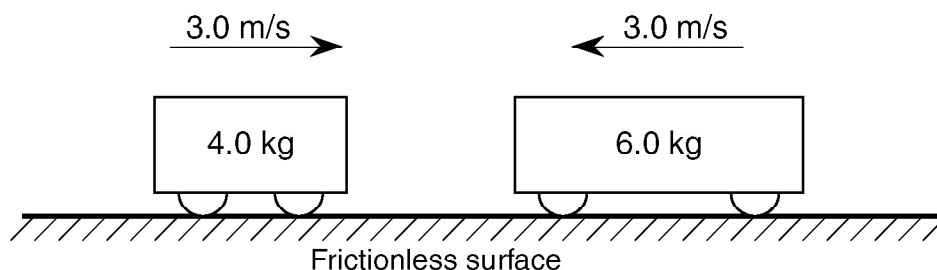
- |  |   |
|--|---|
| 36. The spaceship is moving away from Earth when the radio signal is received. Compared to the frequency of the signal sent from Earth, the frequency of the signal received by the spaceship is<br>1) the same                      3) higher<br>2) lower | 39. A 12.0-meter length of copper wire has a resistance of 1.50 ohms. How long must an aluminum wire with the same cross-sectional area be to have the same resistance?<br>1) 7.32 m                      3) 12.0 m<br>2) 8.00 m                      4) 19.7 m |
|--|---|
40. In the circuit diagram below, what are the correct readings of voltmeters  $V_1$  and  $V_2$ ?



- |  |       |
|--|-------|
| 1) $V_1$ reads 3.0 V and $V_2$ reads 3.0 V | _____ |
| 2) $V_1$ reads 6.0 V and $V_2$ reads 6.0 V | _____ |
| 3) $V_1$ reads 4.0 V and $V_2$ reads 2.0 V | _____ |
| 4) $V_1$ reads 2.0 V and $V_2$ reads 4.0 V | _____ |



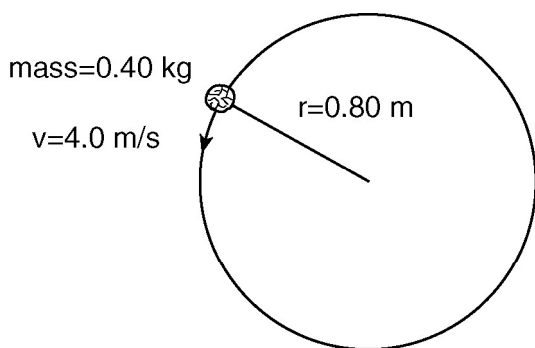
41. The diagram below shows a 4.0-kilogram cart moving to the right and a 6.0-kilogram cart moving to the left on a horizontal frictionless surface.



When the two carts collide they lock together. The magnitude of the total momentum of the two-cart system after the collision is

- 1) 0.0 kg•m/s      2) 6.0 kg•m/s      3) 15 kg•m/s      4) 30. kg•m/s

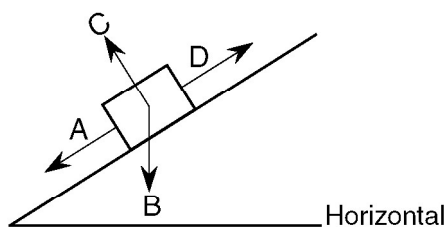
42. The diagram below represents a 0.40-kilogram stone attached to a string. The stone is moving at a constant speed of 4.0 meters per second in a horizontal circle having a radius of 0.80 meter.



The magnitude of the centripetal acceleration of the stone is

- 1) 0.0 m/s<sup>2</sup>      3) 5.0 m/s<sup>2</sup>  
2) 2.0 m/s<sup>2</sup>      4) 20. m/s<sup>2</sup>

43. In the diagram below, a box is at rest on an inclined plane.



Which vector best represents the direction of the normal force acting on the box?

- 1) A      3) C  
2) B      4) D

44. How much work is required to move a single electron through a potential difference of 100. volts?

- 1)  $1.6 \times 10^{-19}$  J      3)  $1.6 \times 10^{-17}$  J  
2)  $1.6 \times 10^{-18}$  J      4)  $1.0 \times 10^{-17}$  J

45. The speed of a car is increased uniformly from 20. meters per second to 30. meters per second in 4.0 seconds. The magnitude of the car's average acceleration in this 4.0-second interval is

- 1) 0.40 m/s<sup>2</sup>      3) 10. m/s<sup>2</sup>  
2) 2.5 m/s<sup>2</sup>      4) 13 m/s<sup>2</sup>

46. A monochromatic ray of light ( $f = 5.09 \times 10^{14}$  hertz) traveling in air is incident upon medium A at an angle of  $45^\circ$ . If the angle of refraction is  $29^\circ$ , medium A could be

- 1) flint glass      3) fused quartz  
2) water      4) Lucite

47. The centers of two 15.0-kilogram spheres are separated by 3.00 meters. The magnitude of the gravitational force between the two spheres is approximately

- 1)  $5.00 \times 10^{-10}$  N      3)  $1.11 \times 10^{-10}$  N  
2)  $1.67 \times 10^{-10}$  N      4)  $3.34 \times 10^{-10}$  N

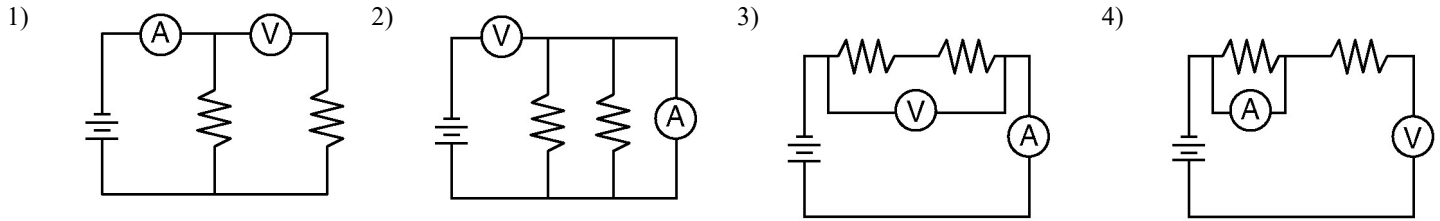
48. A net force of 25 Newtons is applied horizontally to a 10.-kilogram block resting on a table. What is the magnitude of the acceleration of the block?

- 1) 0.0 m/s<sup>2</sup>      3) 0.40 m/s<sup>2</sup>  
2) 0.26 m/s<sup>2</sup>      4) 2.5 m/s<sup>2</sup>

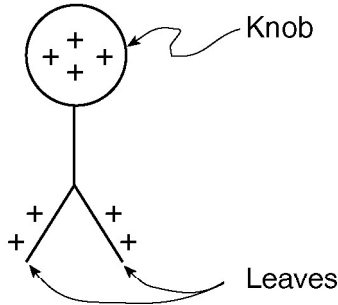
49. A 0.500-meter length of wire with a cross-sectional area of  $3.14 \times 10^{-6}$  meters squared is found to have a resistance of  $2.53 \times 10^{-2}$  ohms. According to the resistivity chart, the wire could be made of

- 1) copper      3) nichrome  
2) aluminum      4) silver

50. Which circuit diagram shows voltmeter V and ammeter A correctly positioned to measure the total potential difference of the circuit and the current through each resistor?



51. An electroscope is a device with a metal knob, a metal stem, and freely hanging metal leaves used to detect charges. The diagram below shows a positively charged leaf electroscope.



As a positively charged glass rod is brought near the knob of the electroscope, the separation of the electroscope leaves will

- 1) decrease
- 2) increase
- 3) remain the same

52. Which combination of quarks would produce a neutral baryon?

- 1)  $\bar{u}dd$
- 2)  $udd$
- 3)  $\bar{u}\bar{u}d$
- 4)  $uud$

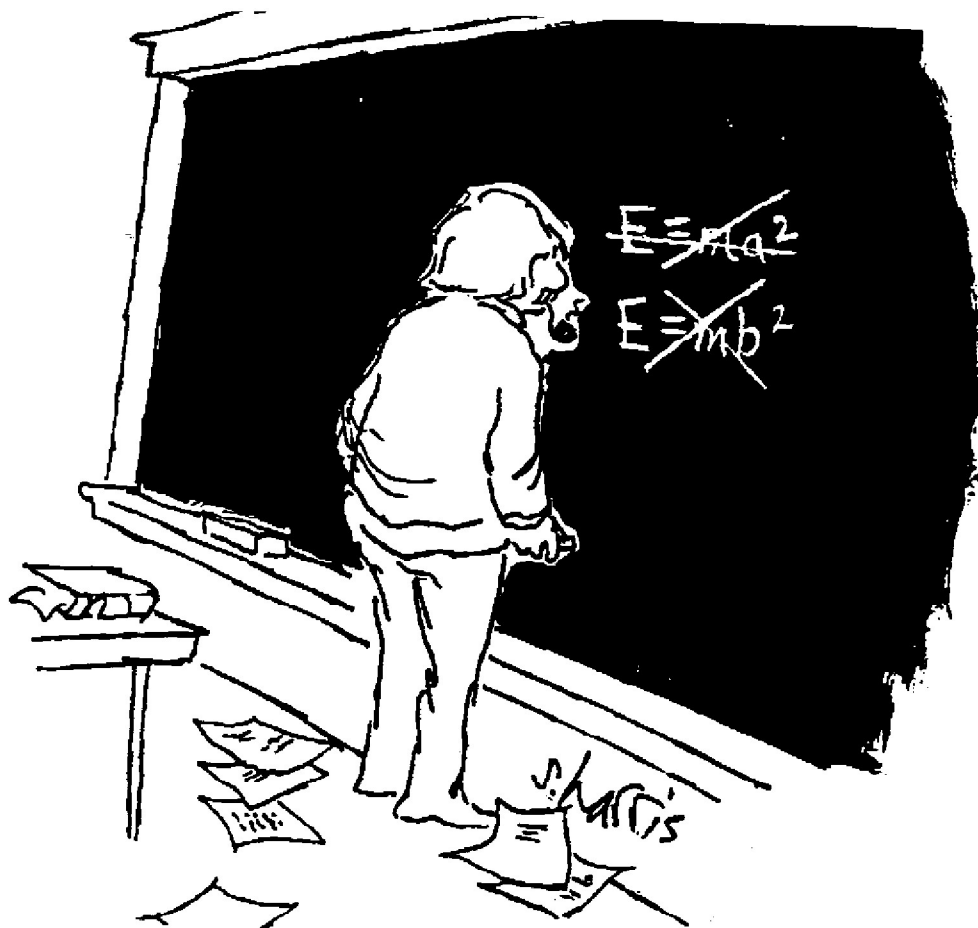
53. An apple weighing 1 Newton on the surface of Earth has a mass of approximately

- 1)  $1 \times 10^{-1}$  kg
- 2)  $1 \times 10^1$  kg
- 3)  $1 \times 10^{-2}$  kg
- 4)  $1 \times 10^2$  kg

54. A physics student notices that 4.0 waves arrive at the beach every 20. seconds. The frequency of these waves is

- 1) 0.20 Hz
- 2) 5.0 Hz
- 3) 16 Hz
- 4) 80. Hz

55. Base your answer to the following question on the cartoon below and your knowledge of physics.



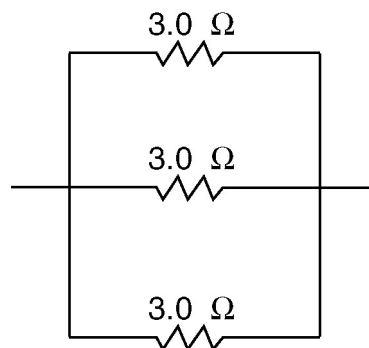
In the cartoon, Einstein is contemplating the equation for the principle that

- 1) energy is emitted or absorbed in discrete packets called photons
- 2) mass always travels at the speed of light in a vacuum
- 3) the fundamental source of all energy is the conversion of mass into energy
- 4) the energy of a photon is proportional to its frequency

56. In which situation is the net force on the object equal to zero?

- 1) a bicycle moving at constant speed on a straight, level road
- 2) an automobile braking to a stop
- 3) a satellite moving at constant speed around Earth in a circular orbit
- 4) a pitched baseball being hit by a bat

57. What is the total resistance of the circuit segment shown in the diagram below?



- |          |          |
|----------|----------|
| 1) 1.0 Ω | 3) 3.0 Ω |
| 2) 9.0 Ω | 4) 27 Ω  |

58. An electric guitar is generating a sound of constant frequency. An increase in which sound wave characteristic would result in an increase in loudness?

- 1) period
- 2) wavelength
- 3) speed
- 4) amplitude

59. During a collision, an 84-kilogram driver of a car moving at 24 meters per second is brought to rest by an inflating air bag in 1.2 seconds. The magnitude of the force exerted on the driver by the air bag is approximately

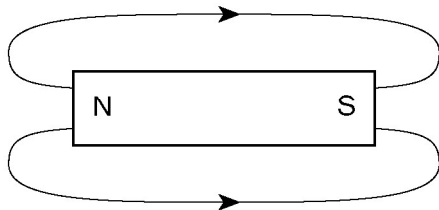
- 1)  $7.0 \times 10 \text{ N}$
- 2)  $8.2 \times 10 \text{ N}$
- 3)  $1.7 \times 10 \text{ N}$
- 4)  $2.0 \times 10 \text{ N}$

60. Which diagram best represents magnetic flux lines around a bar magnet?

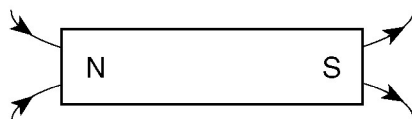
1)



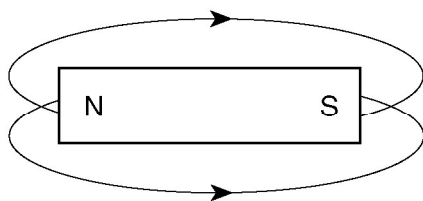
2)



3)



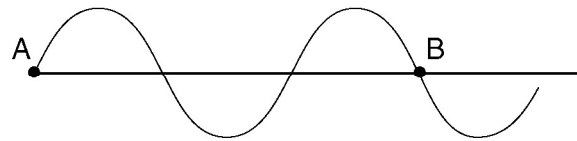
4)



61. An object can *not* have a charge of

- 1)  $3.2 \times 10 \text{ C}$
- 2)  $4.5 \times 10 \text{ C}$
- 3)  $8.0 \times 10 \text{ C}$
- 4)  $9.6 \times 10 \text{ C}$

62. The diagram below shows two points, *A* and *B*, on a wave train.



How many wavelengths separate point *A* and point *B*?

- 1) 1.0
- 2) 1.5
- 3) 3.0
- 4) 0.75

63. A 1.0-kilogram rubber ball traveling east at 4.0 meters per second hits a wall and bounces back toward the west at 2.0 meters per second. Compared to the kinetic energy of the ball before it hits the wall, the kinetic energy of the ball after it bounces off the wall is

- 1) one-fourth as great
- 2) one-half as great
- 3) the same
- 4) four times as great

64. As a spring is stretched, its elastic potential energy

- 1) decreases
- 2) increases
- 3) remains the same

65. What type of nuclear force holds the protons and neutrons in an atom together?

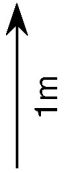
- 1) a strong force that acts over a long range
- 2) a weak force that acts over a short range
- 3) a strong force that acts over a short range
- 4) a weak force that acts over a long range

66. A roller coaster, traveling with an initial speed of 15 meters per second, decelerates uniformly at  $-7.0$  meters per second to a full stop. Approximately how far does the roller coaster travel during its deceleration?

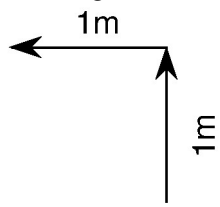
- 1) 1.0 m
- 2) 2.0 m
- 3) 16 m
- 4) 32 m

67. Which vector diagram represents the greatest magnitude of displacement for an object?

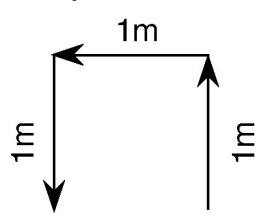
1)



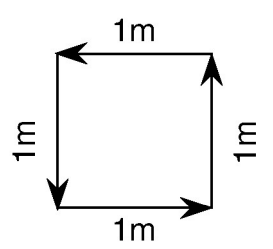
2)



3)



4)



## Reference Tables

## List of Physical Constants

Name	Symbol	Value
Universal gravitational constant	$G$	$6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$
Acceleration due to gravity	$g$	$9.81 \text{ m/s}^2$
Speed of light in a vacuum	$c$	$3.00 \times 10^8 \text{ m/s}$
Speed of sound in air at STP		$3.31 \times 10^2 \text{ m/s}$
Mass of Earth		$5.98 \times 10^{24} \text{ kg}$
Mass of the Moon		$7.35 \times 10^{22} \text{ kg}$
Mean radius of Earth		$6.37 \times 10^6 \text{ m}$
Mean radius of the Moon		$1.74 \times 10^6 \text{ m}$
Mean distance—Earth to the Moon		$3.84 \times 10^8 \text{ m}$
Mean distance—Earth to the Sun		$1.50 \times 10^{11} \text{ m}$
Electrostatic constant	$k$	$8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$
1 elementary charge	$e$	$1.60 \times 10^{-19} \text{ C}$
1 coulomb (C)		$6.25 \times 10^{18} \text{ elementary charges}$
1 electronvolt (eV)		$1.60 \times 10^{-19} \text{ J}$
Planck's constant	$h$	$6.63 \times 10^{-34} \text{ J}\cdot\text{s}$
1 universal mass unit (u)		$9.31 \times 10^2 \text{ MeV}$
Rest mass of the electron	$m_e$	$9.11 \times 10^{-31} \text{ kg}$
Rest mass of the proton	$m_p$	$1.67 \times 10^{-27} \text{ kg}$
Rest mass of the neutron	$m_n$	$1.67 \times 10^{-27} \text{ kg}$